



Results from CrIS/ATMS Obtained Using the AIRS Science Team Retrieval Methodology

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Background

CrIS is the infrared high spectral resolution atmospheric sounder launched on Suomi-NPP in 2011

CrIS/ATMS comprise the IR/MW Sounding Suite on Suomi-NPP

CrIS is functionally equivalent to AIRS, the high spectral resolution IR sounder launched on EOS Aqua in 2002 and ATMS is functionally equivalent to AMSU on EOS Aqua

CrIS is an interferometer and AIRS is a grating spectrometer

Spectral coverage, spectral resolution, and channel noise of CrIS is similar to AIRS

CrIS spectral sampling is roughly twice as coarse as AIRS

AIRS has 2378 channels between 650 cm^{-1} and 2665 cm^{-1}

CrIS has 1305 channels between 650 cm^{-1} and 2550 cm^{-1}

Spatial resolution of CrIS is comparable to AIRS

Background (Cont.)

The AIRS Science Team Version 6 retrieval algorithm is currently producing very high quality level-3 Climate Data Records (CDRs) from AIRS that will be critical for understanding climate processes. CDRs include all cases passing AIRS Climate QC

AIRS CDRs should eventually cover the period September 2002 through at least 2020

CrIS/ATMS is the only scheduled follow on to AIRS/AMSU

This research is being done to answer the question of whether CrIS/ATMS can be counted on to adequately continue AIRS/AMSU CDRs beyond 2020, or is something better needed?

A minimum requirement to obtain a yes answer may be that CrIS/ATMS be analyzed using an AIRS Version 6-like retrieval algorithm

NOAA is currently generating CrIS/ATMS products using 2 algorithms: IDPS and NUCAPS. We will investigate the CDR capabilities of these algorithms as well.

Overview of AIRS/AMSU Version-6 Retrieval Methodology

AIRS Version 6 is a physically based retrieval system

Uses cloud cleared radiances \hat{R}_i to determine the state vector X

\hat{R}_i represents what AIRS would have seen in the absence of clouds

Basic steps

- 1) Generate a Neural-Net based initial guess X^0 using AIRS/AMSU observations R_i
- 2) Generate cloud clearing coefficients that provide \hat{R}_i for all channels
- 3) Sequentially determine: T_s , $T(p)$, $q(p)$, $O_3(p)$, $CO(p)$, and $CH_4(p)$ using \hat{R}_i in subsets of channels i selected for each step
 - Finds state X such that $R_i(X)$ best match \hat{R}_i where $R_i(X)$ is the computed radiance for state X
- 4) Derive cloud parameters such that $R_i(X^{CLD})$ best matches observed radiances R_i where X^{CLD} is final state vector including cloud parameters
- 5) Compute Outgoing Longwave Radiation (OLR) using an OLR Radiative Transfer Algorithm in conjunction with X^{CLD}
- 6) Generate QC flags for all parameters
 - QC=0 passes Data Assimilation QC; QC=1 passes Climate QC

SRT Research Using CrIS/ATMS

Approach

Analyze CrIS/ATMS using methodology as closely as possible to AIRS Version 6

SRT CrIS/ATMS Version 5.70 is analogous to AIRS/AMSU Version 6 but uses a regression based guess instead of a Neural-Net guess

Like AIRS Version 6, CrIS/ATMS Version 5.70 uses only shortwave CrIS window channels to determine surface skin temperature T_s , and uses only shortwave CO₂ channels to determine tropospheric $T(p)$

Using only shortwave window channels and shortwave tropospheric sounding channels allows for better soundings under harder cloud conditions

We have recently obtained CrIS/ATMS Neural-Net coefficients for CrIS/ATMS from Bill Blackwell, but they have not yet been successfully implemented at SRT

We plan to optimize and run Version 6-like CrIS/ATMS retrievals when the CrIS/ATMS Neural-Net capability is functioning

The CrIS/ATMS IDPS Retrieval Algorithm

IDPS products are generated using an improved version of a heritage NGAS retrieval algorithm

IDPS generates surface skin temperature (T_s), temperature profile $T(p)$, moisture profile $q(p)$, and pressure profile

IDPS has a single product independent QC flag

IDPS does not generate level-3 products

The current version is IDPS Mx 7.1, which became operational July 2013

We have been able to read and evaluate IDPS Mx 7.1 level-2 products and also generate IDPS level-3 products using the IDPS QC flag

NOAA Unique CrIS/ATMS Processing System (NUCAPS)

The NUCAPS retrieval algorithm was developed by Chris Barnet and co-workers at NOAA/NESDIS/STAR

NUCAPS is based on earlier AIRS Science Team retrieval algorithms and produces most products AIRS Version 6 does

Possible limitations of NUCAPS with regard to generation of optimal CDRs:

Channels used and QC methodology are not up to date with AIRS Version 6

NUCAPS does not use a Neural-Net guess

Use of a Neural-Net guess improved AIRS Version 6 temperature profiles considerably

Like IDPS, NUCAPS has only a single product independent QC flag and does not generate level-3 products

We have evaluated NUCAPS level-2 products and generated level-3 products using the NUCAPS QC flag

Comparisons Shown

Results are shown on July 11, 2013 for T_s and $T(p)$

First comparisons show level-2 AIRS/AMSU Version 6 (called AIRS) and CrIS/ATMS Version 5.70 (called CrIS) results using both tight Data Assimilation (DA) QC and looser Climate QC thresholds. Achieving AIRS/AMSU Version 6 quality results is the goal for CrIS/ATMS, especially from the climate perspective

Second comparisons show level-2 and level-3 AIRS, CrIS, IDPS CrIS/ATMS (called IDPS) , and NUCAPS CrIS/ATMS (called NUCAPS) products

AIRS and CrIS results use their climate QC flags

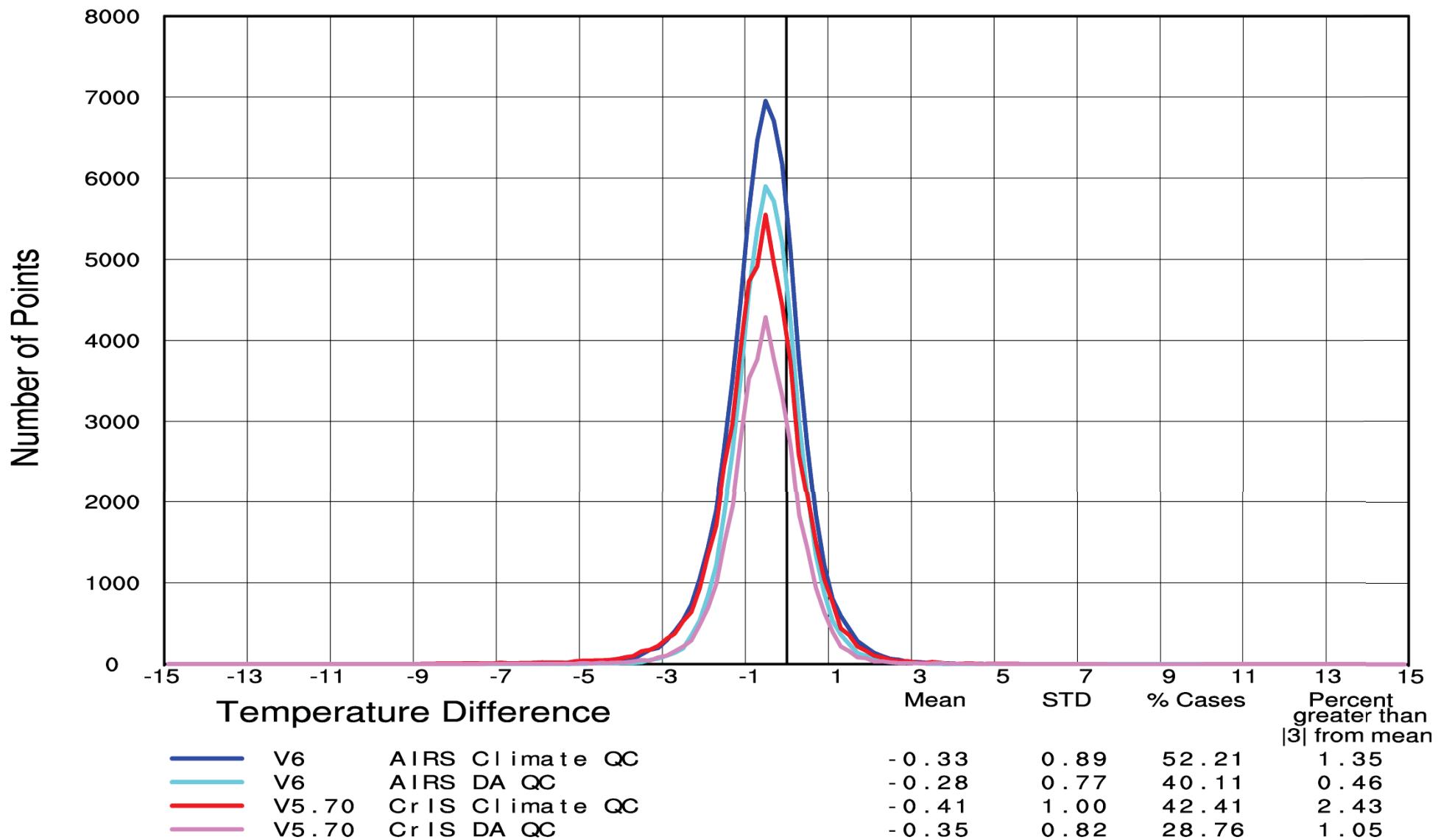
IDPS and NUCAPS results use their own QC flags

We also compare CrIS and NUCAPS results for common ensembles

CrIS and NUCAPS retrievals each using CrIS Climate QC flag

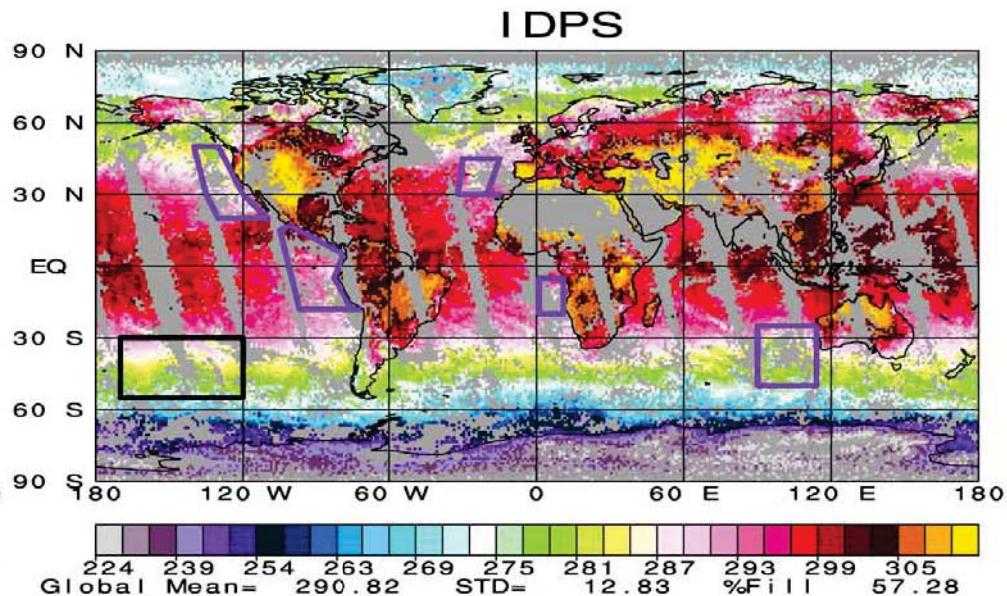
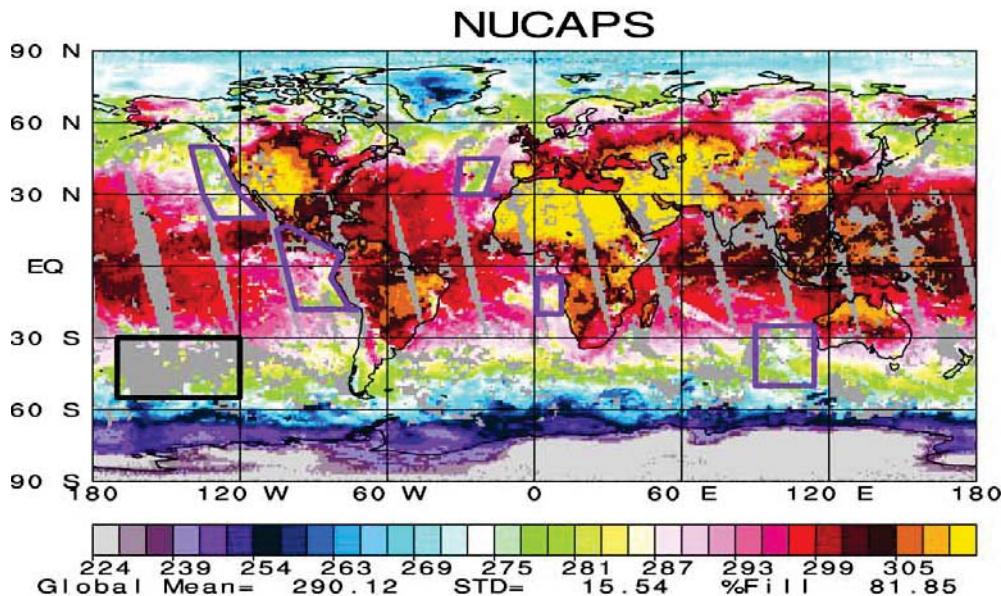
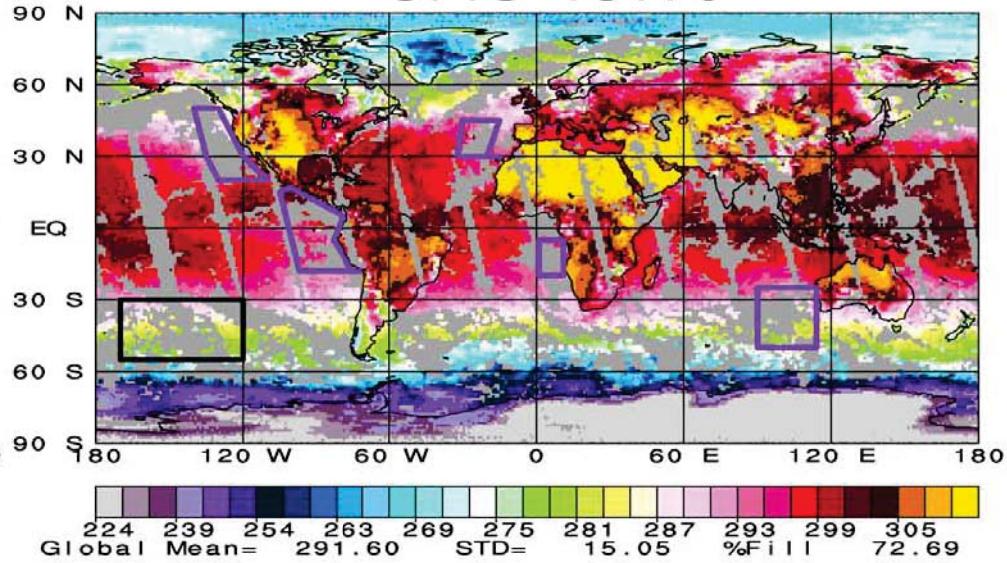
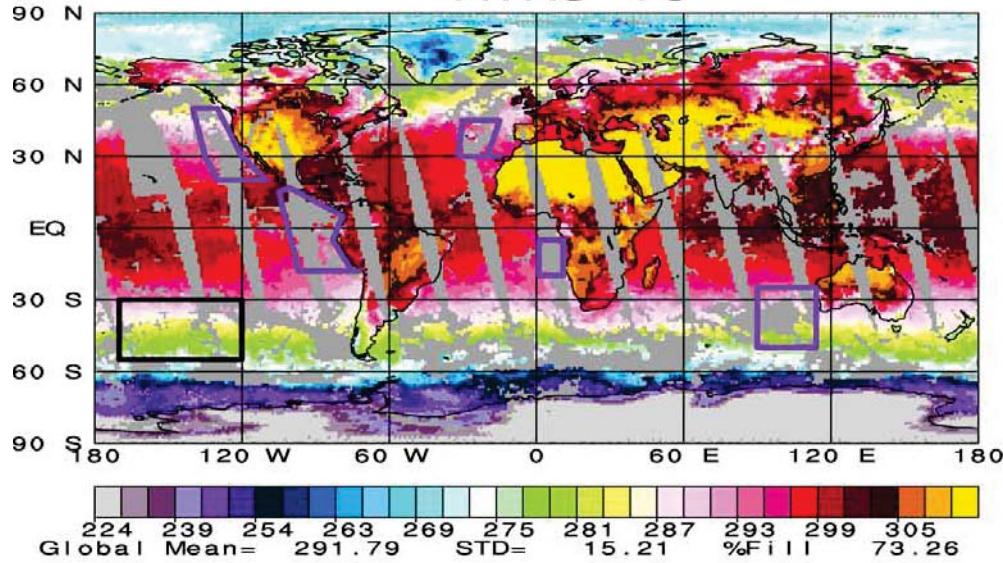
CrIS and NUCAPS retrievals each using NUCAPS QC flag

Surface Skin Temperature Difference from ECMWF
 July 11, 2013 Daytime and Nighttime
 50°N to 50°S Non-Frozen Ocean



QC'd CrIS SSTs are reasonably good but QC'd AIRS SSTs are much better. CrIS with DA QC has error statistics similar to AIRS with Climate QC, but with a much smaller yield.

July 11, 2013 Surface Skin Temperature (K) 1:30 PM
AIRS V6

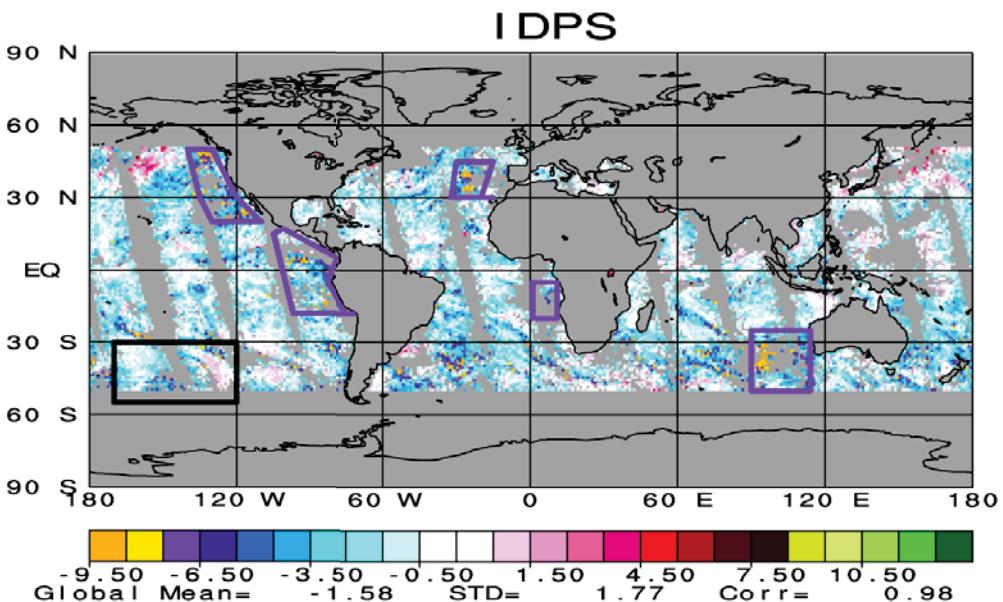
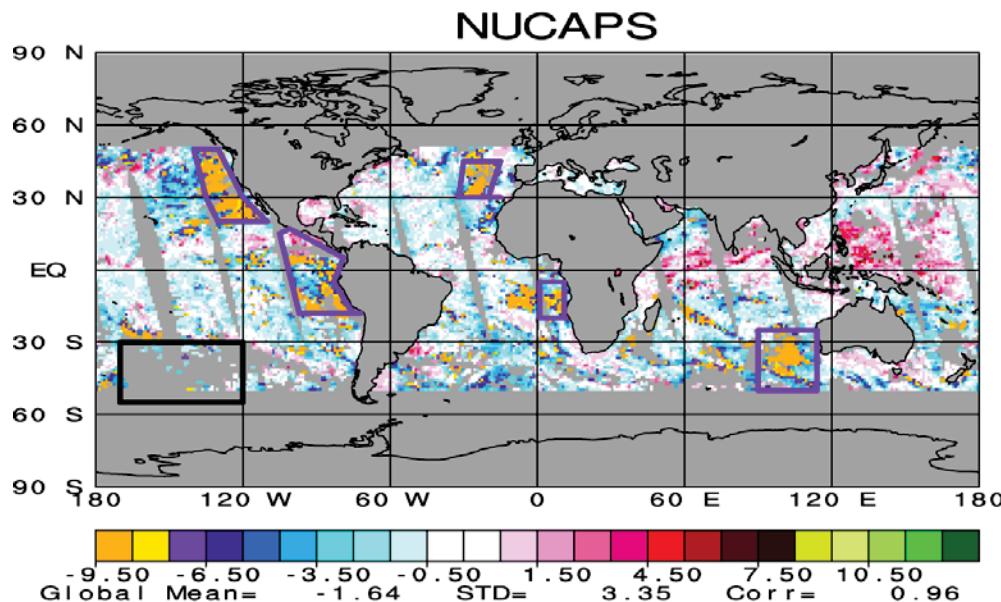
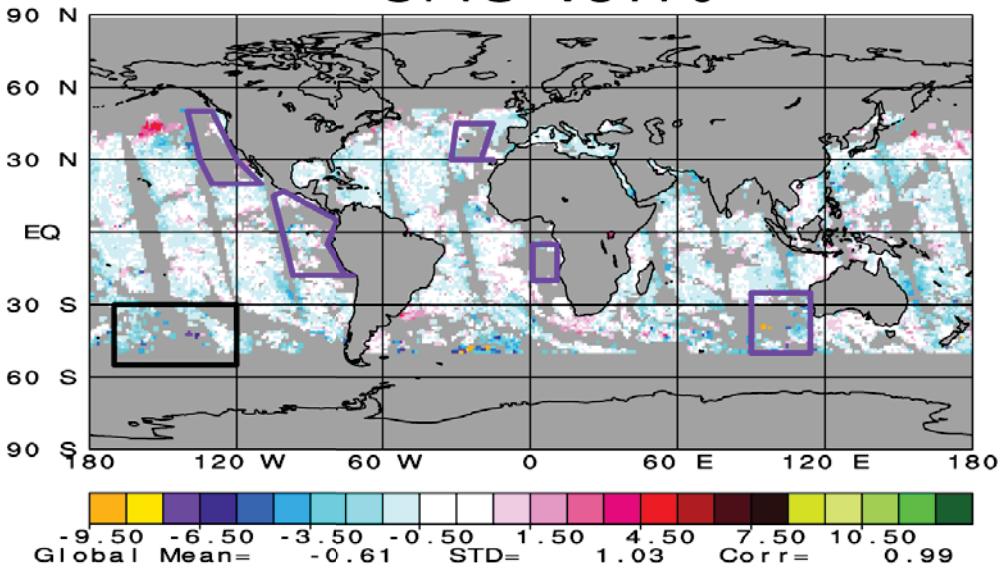
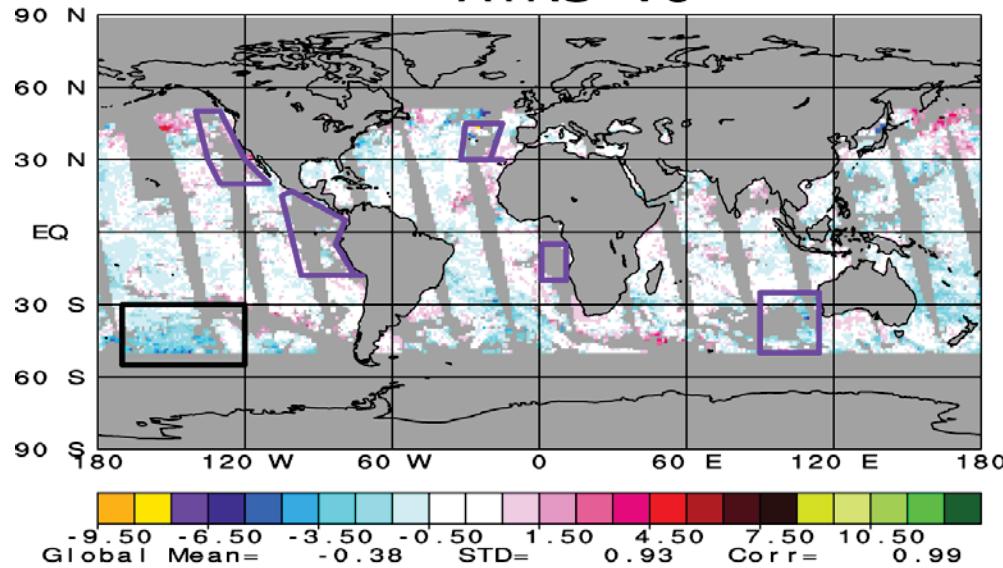


IDPS spatial coverage is poor, especially over hot and cold land. Not suitable for CDRs.

— Areas accepted by NUCAPS QC but rejected by AIRS T_s Climate QC.

— Sample area rejected by NUCAPS QC but accepted by AIRS T_s Climate QC.

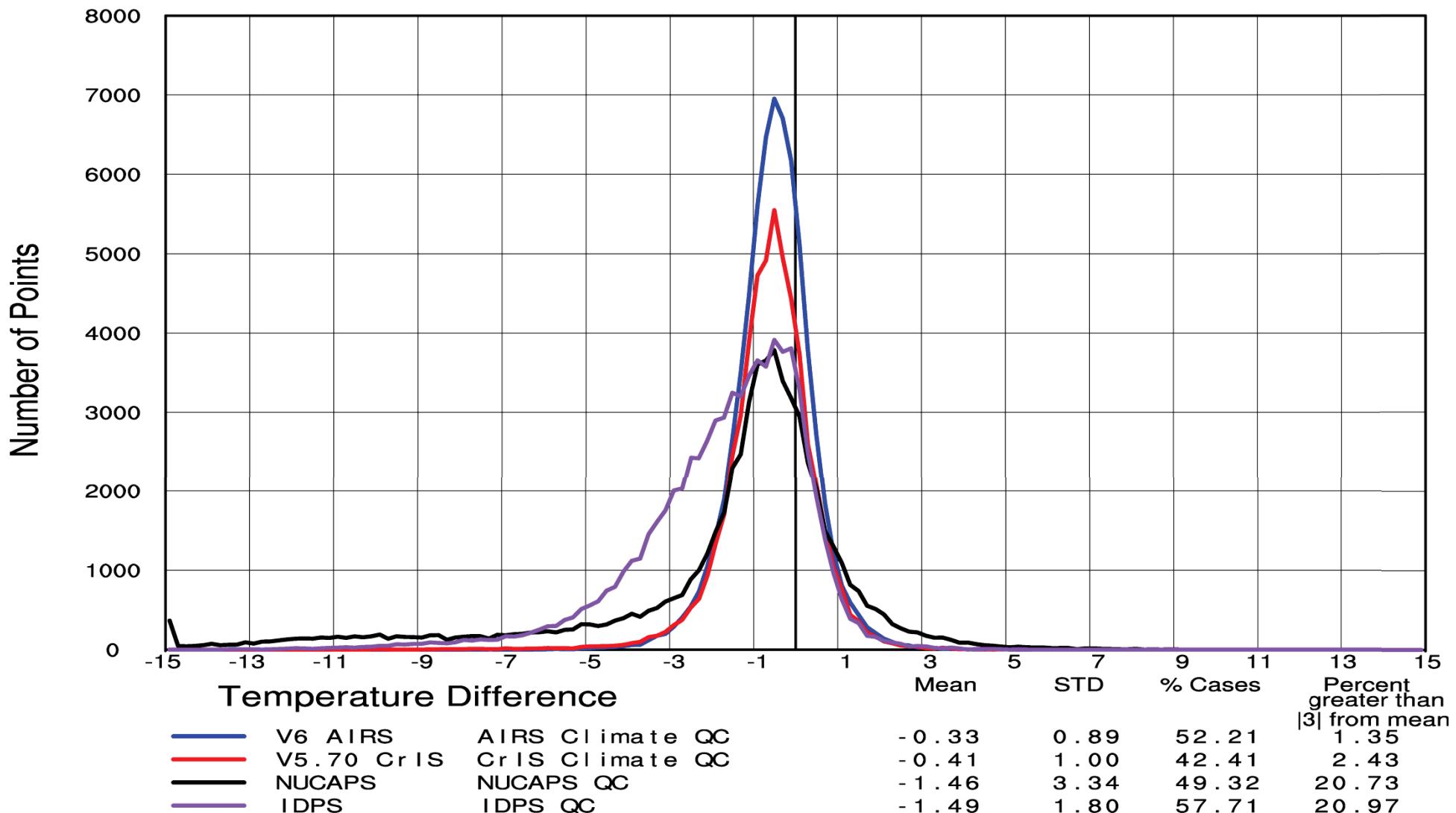
July 11, 2013 Surface Skin Temperature (K) 1:30 PM
 Difference from ECMWF 50°N to 50°S Ocean
 AIRS V6



IDPS SST retrievals are biased cold almost everywhere.

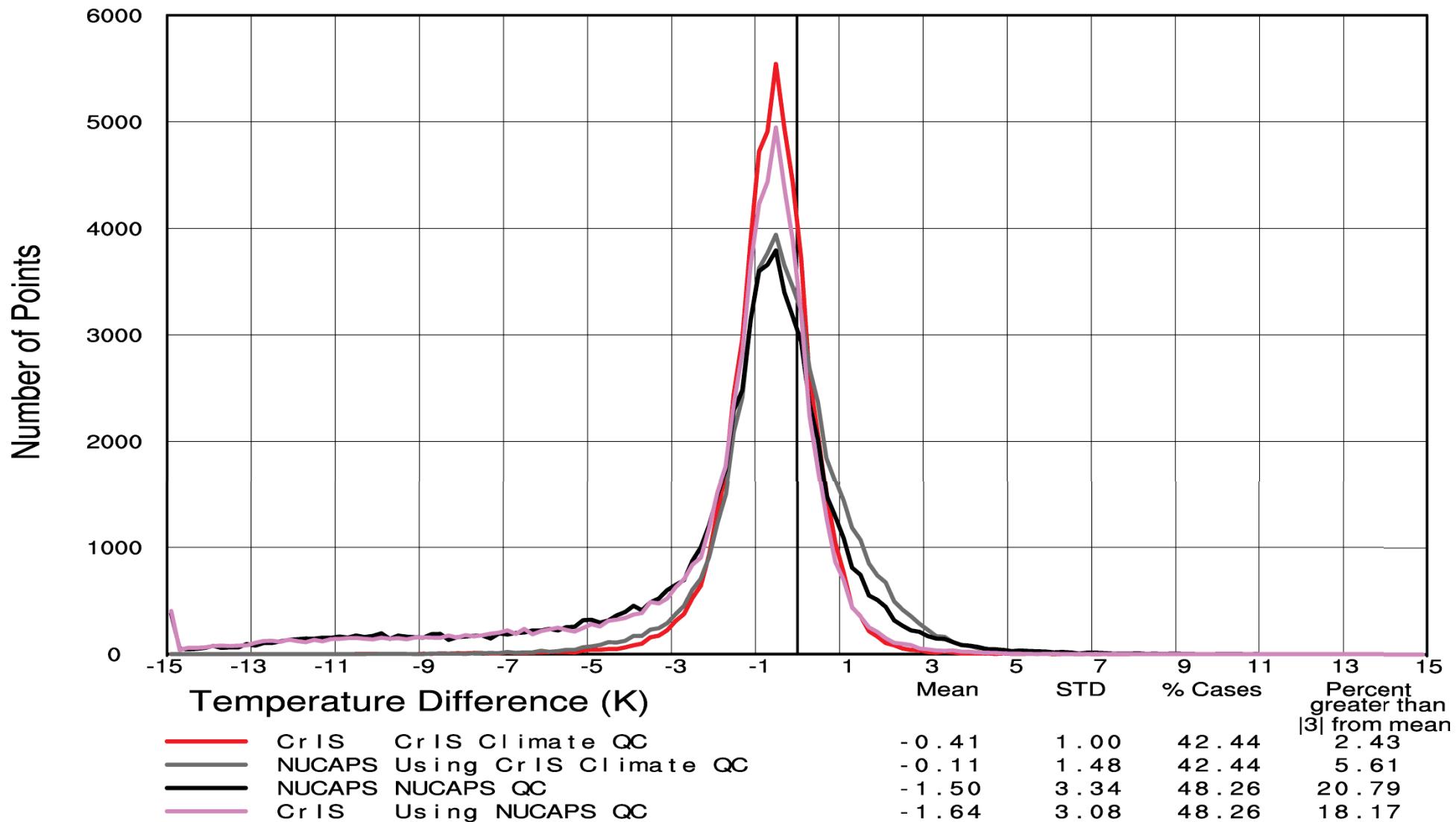
NUCAPS SST retrievals have very large negative errors where AIRS and CrIS reject retrievals.

**Surface Skin Temperature Difference from ECMWF
July 11, 2013 Daytime and Nighttime
50°N to 50°S Non-Frozen Ocean**



QC'd NUCAPS and IDPS SST statistics with their own QC are both very poor. Yields are both high, but more than 20% of their accepted cases are very negative outliers. They also accept much less good cases.

Surface Skin Temperature Difference from ECMWF (K)
 July 11, 2013 Daytime and Nighttime
 50°N to 50°S Non-Frozen Ocean Common Ensembles



CrIS QC eliminates all bad NUCAPS SST retrievals.

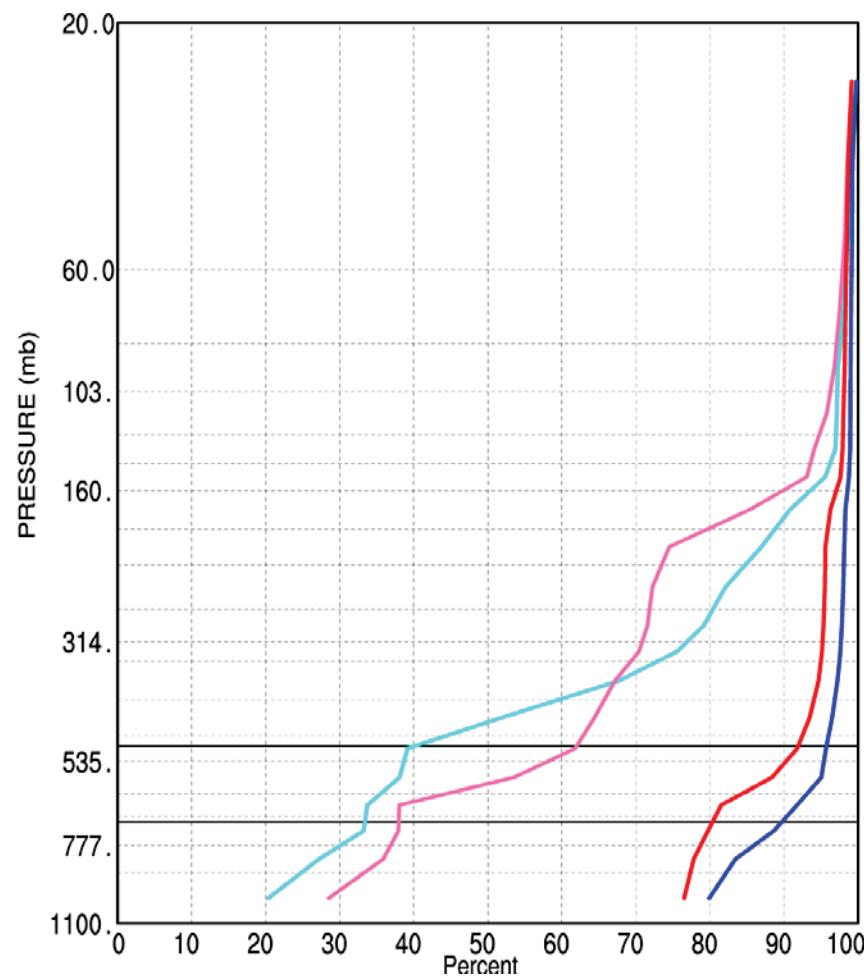
NUCAPS with CrIS QC is significantly poorer than CrIS with CrIS QC.

Global

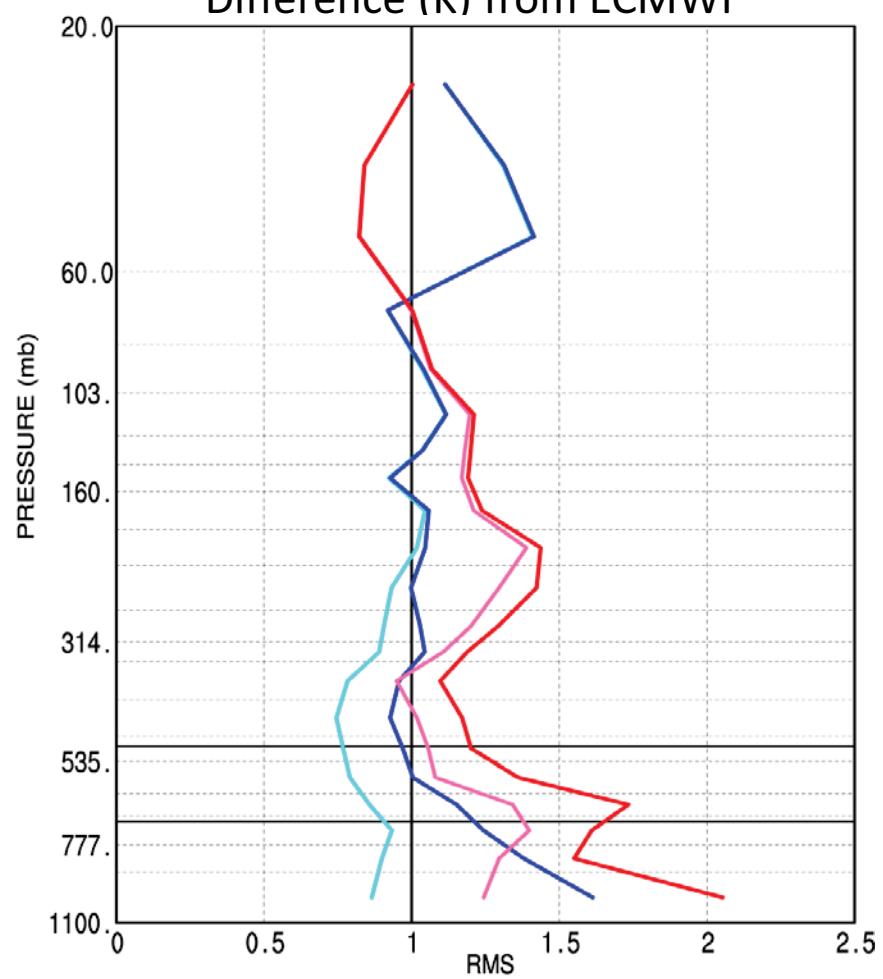
Temperature Profile

July 11, 2013

Percent of All Cases Accepted



RMS 1 km Layer Mean
Difference (K) from ECMWF



— V6	AIRS/AMSU	Data Assimilation QC
— V6	AIRS/AMSU	Climate QC
— V5.70	CrIS/ATMS	Data Assimilation QC
— V5.70	CrIS/ATMS	Climate QC

AIRS with DA QC has errors less than 1K in troposphere.

AIRS with Climate QC has 80% yield at surface and 95% yield at 500 mb.

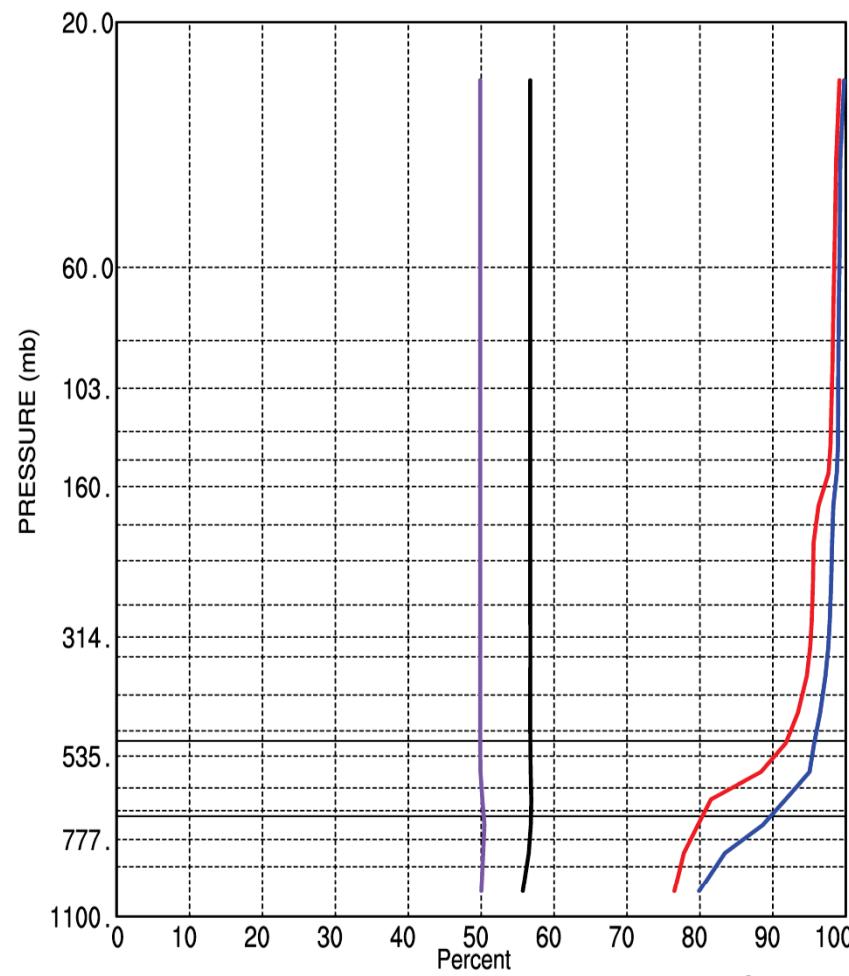
CrIS results are poorer than AIRS – should improve with Neural-Net guess.

Global

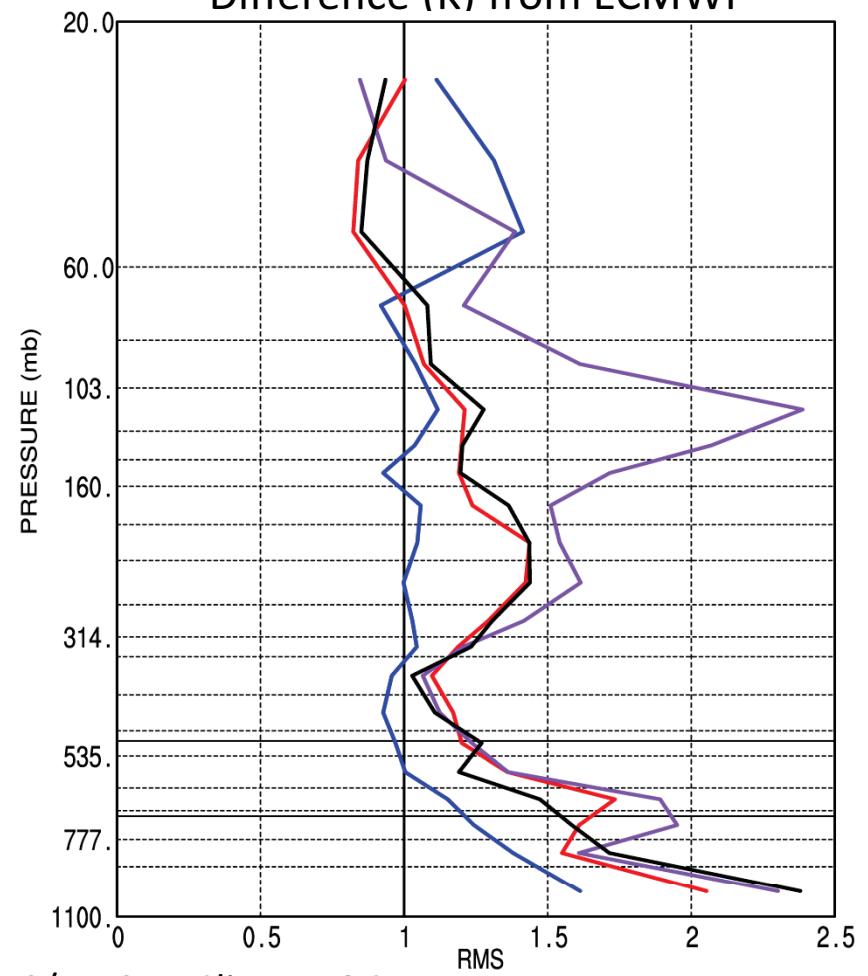
Temperature Profile

July 11, 2013

Percent of All Cases Accepted



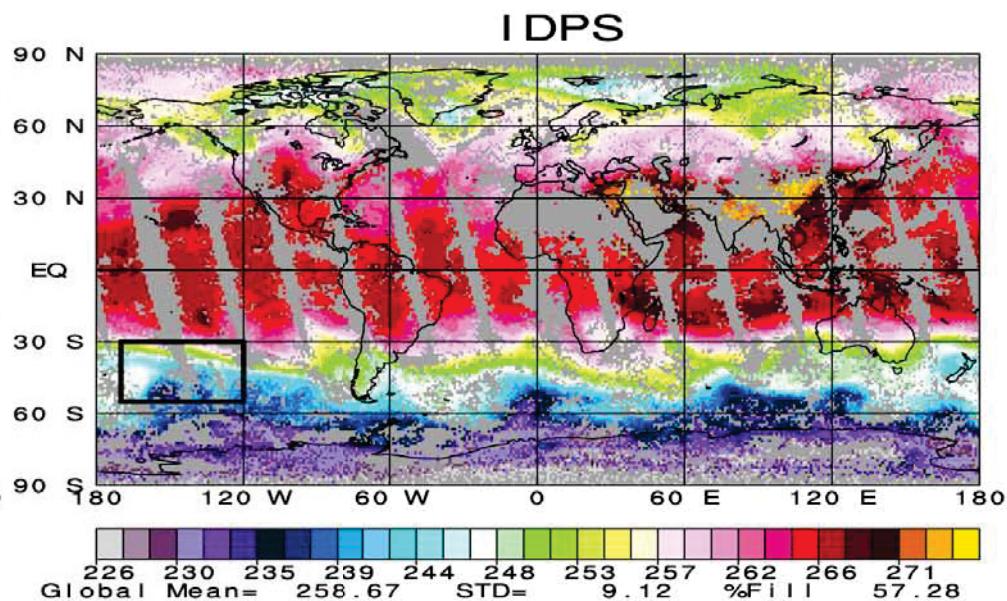
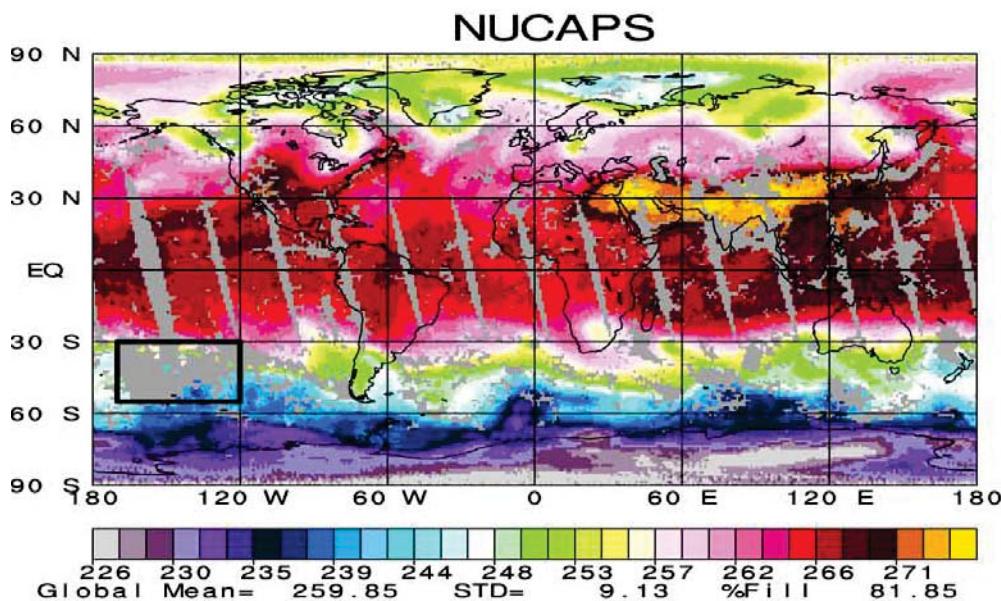
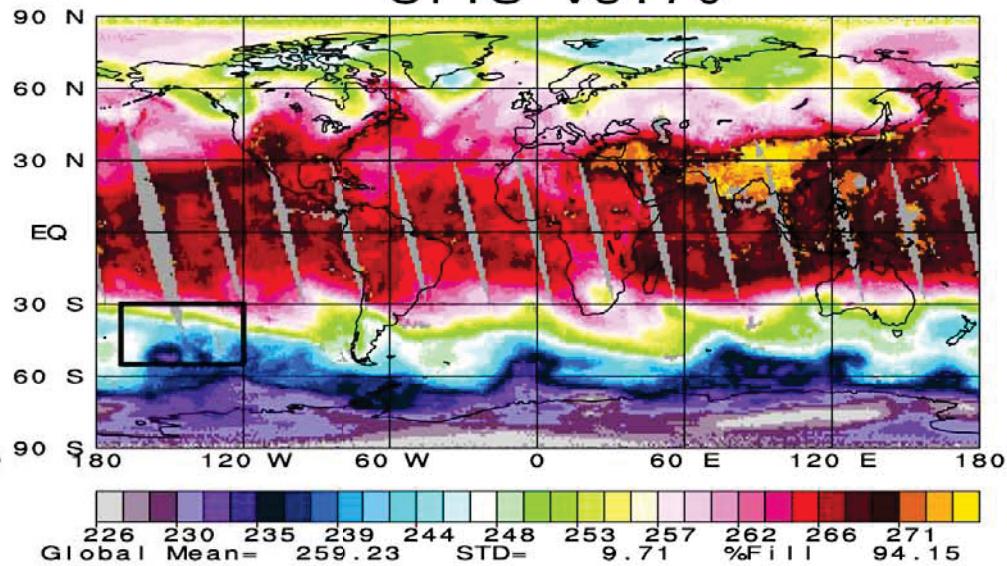
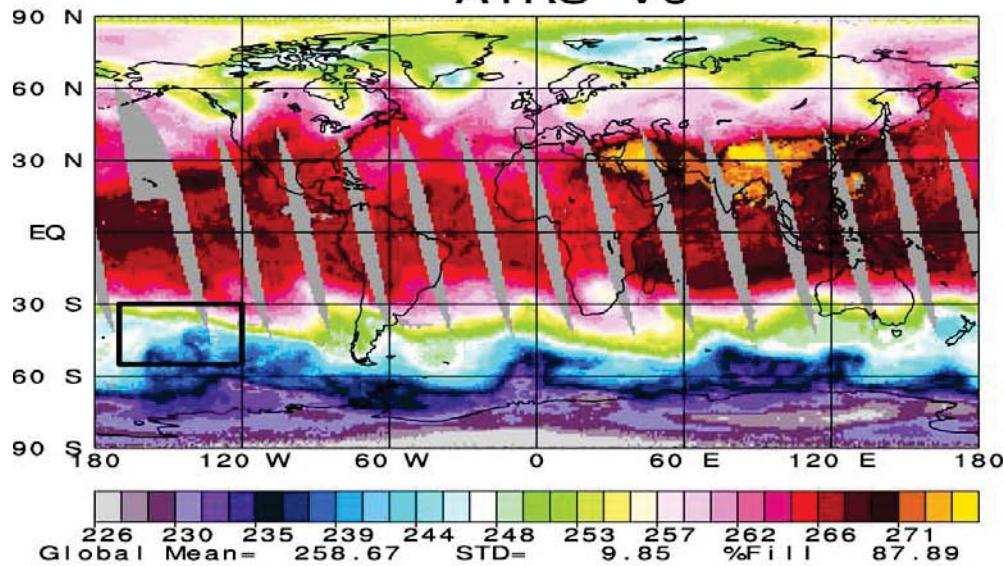
RMS 1 km Layer Mean
Difference (K) from ECMWF



AIRS/AMSU	Climate QC
CrlS/ATMS	Climate QC
CrlS/ATMS	IDPS QC
CrlS/ATMS	NUCAPS QC

IDPS and NUCAPS yields are low – may not be adequate for climate purposes.
NUCAPS errors with NUCAPS QC are comparable to CrlS with Climate QC.
AIRS with Climate QC is much better.

July 11, 2013 500 mb Temperature (K) 1:30 PM
AIRS V6

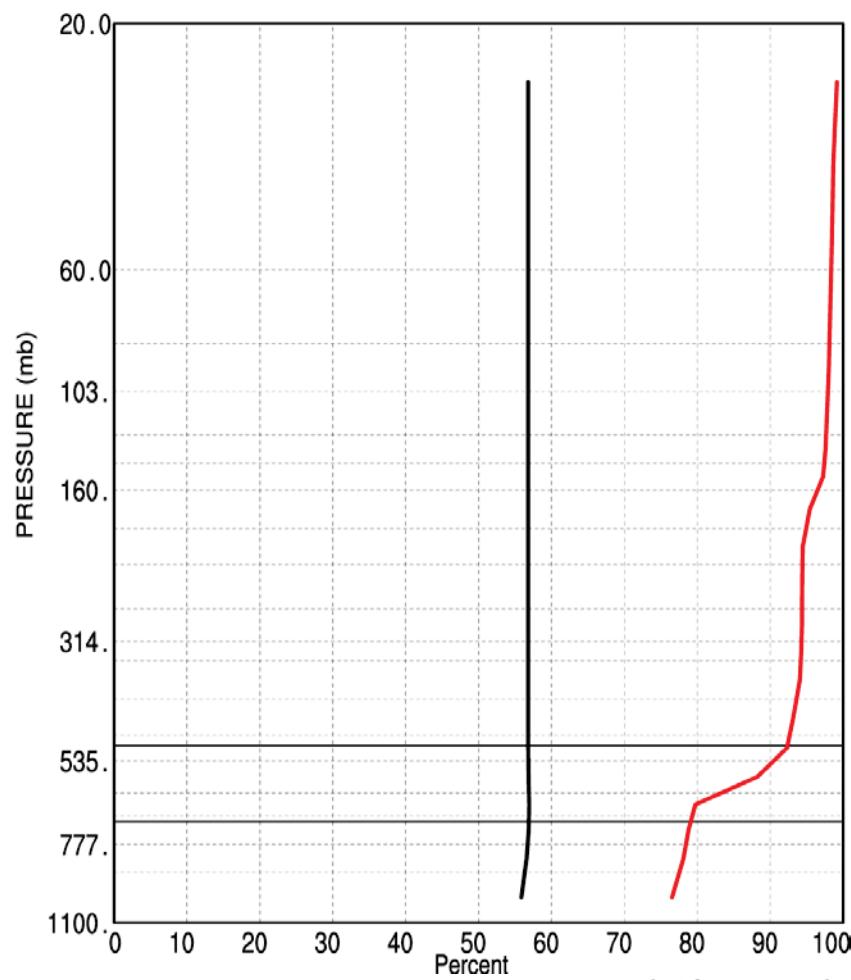


AIRS and CrIS have almost complete spatial coverage at 500 mb.

NUCAPS QC rejects some cold areas south of 30°S. This could bias monthly mean products warm.

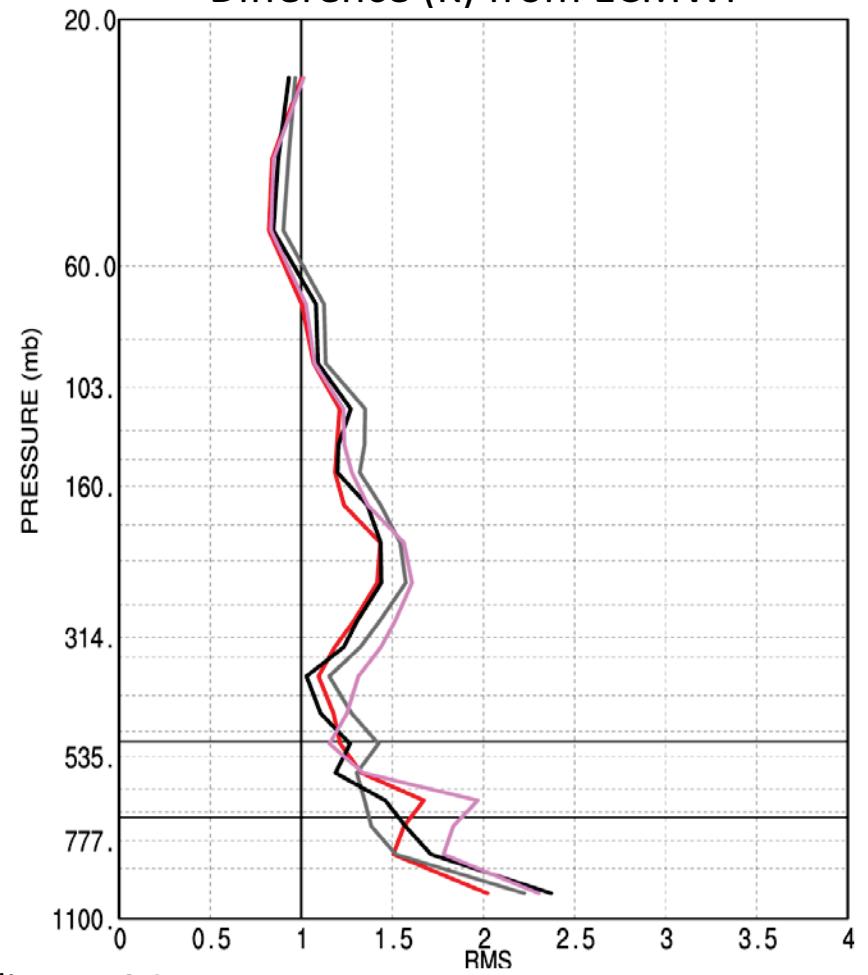
Global Temperature Profile Common Ensembles July 11, 2013

Percent of All Cases Accepted



CrIS	CrIS Climate QC
NUCAPS	using CrIS Climate QC
NUCAPS	using NUCAPS QC
CrIS	using NUCAPS QC

RMS 1 km Layer Mean
Difference (K) from ECMWF



CrIS and NUCAPS retrieval errors are similar to each other with either QC.
Both are poorer than AIRS with Climate QC.

Summary and Plans

CrIS IDPS Mx 7.1 is currently performing very poorly and is not a satisfactory follow-on to AIRS Version 6 – Moreover it does not generate all products

NUCAPS performs better than IDPS but $T(p)$ has poorer spatial coverage than AIRS Version 6 or CrIS Version 5.70. NUCAPS QC eliminates good cases for $T(p)$ and allows bad cases for T_s

We will begin to generate monthly mean NUCAPS level-3 products and compare them with AIRS Version 6: inter-month differences and interannual differences for the same month

Version 5.70 CrIS/ATMS $T(p)$ and T_s are poorer quality than AIRS/AMSU Version 6, especially T_s . This could be a result of truncated CrIS shortwave spectral coverage at 2550 cm^{-1} .

We will begin testing and optimizing CrIS/ATMS Version 6 once the CrIS/ATMS Neural-Net first guess is operating at SST

Once Version 6 CrIS/ATMS is optimized, we hope to generate monthly mean level-3 products for a number of months and compare with AIRS Version 6 and NUCAPS

